CWA Section 319(h): Summary Page
Best Management Practice Verification Project

Title of Project: Best Management Practice (BMP) verification using observed water quality data and watershed planning for implementation of BMPs.

Project Goals/Objectives: The goals of the project are to verify the effectiveness of BMPs installed on a portion (Mill Creek) of the Richland-Chambers reservoir watershed to provide supporting information for BMP implementation within the entire Richland-Chambers reservoir watershed. The specific objectives are 1) Verify the effectiveness of BMPs implemented by analyzing observed water quality data, 2) Develop a methodology/modeling approach to make quantitative assessment of the effectiveness of BMPs in reducing non-point source pollution (NPS), and 3) Spatial and temporal analysis of the impacts of BMPs on water quality.

Project Tasks: 1) Develop a Quality Assurance Project Plan, 2) Watershed data collection and analysis, 3) Modeling of the BMPs at field and watershed scales, 4) Representation of the pre- and post- BMPs conditions in the modeling approach, 5) Model calibration and validation with observed data, 6) Evaluation of the impacts of BMPs on water quality, and 7) Spatial and temporal analysis of the impacts of BMPs.

Project Type: Watershed Planning/Assessment (X);
Statewide ( ) Watershed (X) Demonstration ( ) TMDL ( )

Waterbody Type: River (X) Groundwater ( ) Other ( ) Reservoir(X)

Project Location: Richland Creek (Segment 0837), Chambers Creek (Segment 0814) and Richland-Chambers reservoir (Segment 0836) in the Trinity River Basin in North-Central Texas; Hydrologic Catalog Units: 12030108 and 12030109 (Figure.1)

NPS Management Program Reference: 1999 Texas Non-Point Source Assessment Report and Management Program

NPS Assessment Report Status: Impaired (X) Impacted ( ) Threatened ( )

Key Project Activities: Hire Staff (X); Monitoring ( ); Regulatory Assistance ( ); Technical Assistance (X); Education ( ); Implementation ( ); Demonstration ( ); Other ( )

NPS Management Program Elements: The proposed project will advance toward the milestones numbers 5, 6, and 7 mentioned in the 1999 Texas Nonpoint Source Assessment Report and Management Program. The milestones are 5) analyze and evaluate information 6) quantify impacts and sources, and 7) develop management strategies.

Project Costs: Federal ($237,722); Non-Federal Match ($160,026); Total Project ($397,748)

Project Contractor: Texas Agricultural Experiment Station – Blackland Research and Extension Center, Temple, TX and Spatial Science Laboratory, College Station, TX

Project Period: 3 years from start date (6/2005 – 5/2008)

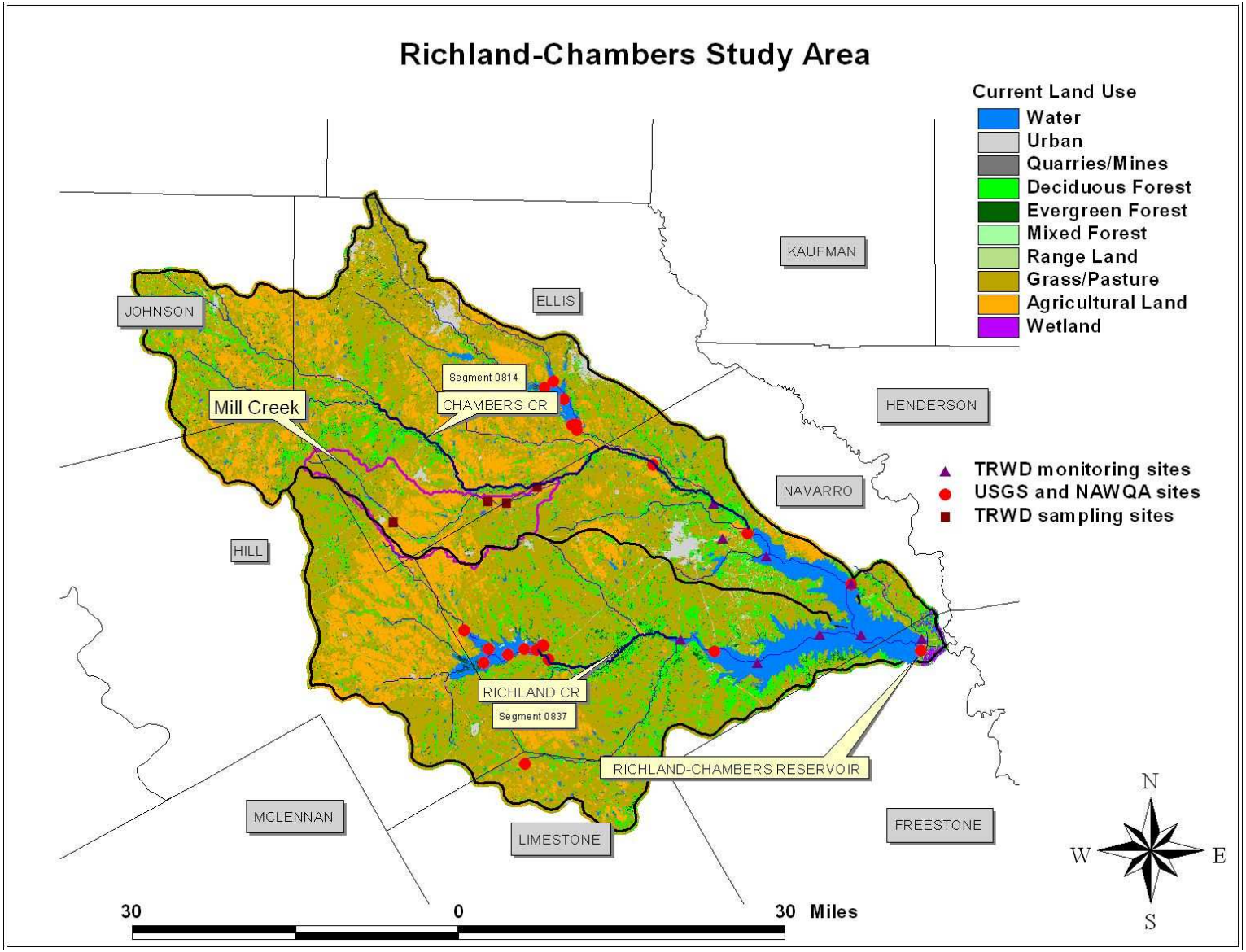

Figure 1. Richland-Chambers Study Area.

WORKPLAN

Verification of the Best Management Practices implemented in Richland-Chambers Watershed

FY05 CWA Section 319(h)

Problem/Need Statement: Richland-Chambers reservoir is the largest among the four major water supply reservoirs maintained by the Tarrant Regional Water District (TRWD) that supplies water to a major portion of the 1.5 million people in North-Central Texas. Segment 0814 – Chambers Creek is listed under category "5c" in 2002 303(d) list for water quality impairment due to depressed dissolved oxygen and partially supporting aquatic life use. Segment 0836 – Richland-Chambers Reservoir is listed under category "5c" in 2002 303(d) list for water quality impairment due to high pH and partially supporting general use. In the draft 2004 303(d) list, nutrient enrichment and algal growth due to excess nitrate and nitrite is listed as a concern at the Richland-Chambers Reservoir in addition to the high pH. Hence these segments have been identified as areas of concern at the Richland-Chambers watershed area. These segments are listed as category 5c with a rank D indicating that additional data and information will be collected before a TMDL is scheduled. The proposed study will verify the condition of existing BMPs, and identify areas of non-point source pollution concern at this watershed. The detailed information provided by this study would help State Agencies such as Texas State Soil and Water Conservation Board (TSSWCB) and Texas Commission on Environmental Quality (TCEQ) for scheduling a TMDL.

General Project Description: Richland-Chambers watershed is 515,690 ha in size and is located in North Central Texas approximately 40 miles south of the city of Dallas in Trinity River Basin. Pasture is the dominant landuse (57%) followed by agriculture (20%) and forest land (13%). During the 1960's and 1970's, the Natural Resources Conservation Service (NRCS) identified Chambers creek as one of the tributaries producing the greatest amount of sediment at the Richland-Chambers Reservoir. Intensive surface water monitoring survey of segment 0814 by the Texas Department of Water Resources during 1977, 1983 and 1989 identified depressed levels of dissolved oxygen at the stream especially during the low flow conditions. In October 1993 a three year intensive data collection program was initiated under the National Water-Quality Assessment (NAWQA) program at the Richland-Chambers stream segments and reservoir. The study identified nutrient loading from non-point sources especially fertilizer from croplands and animal manure from cattle ranching as a major water quality issue. The study also identified Mill Creek and the Big Onion Creek (Tributaries of segment 0814 – Chambers Creek) as the major contributors of nutrient load to the stream and the reservoir.

TRWD took a leading role in coordinating the development of a partnership of several stakeholders to implement a program aimed at reducing pollutant loads in the Richland-Chambers Reservoir. Development of this partnership enabled the application of $5 million in funding from the NRCS to implement Best Management Practices aimed at the reduction of sediments and nutrients from the Mill Creek watershed. Additionally, the District has provided funding to assist in partially satisfying the local match requirements associated with using the federal funds. As a result of this program, a number of BMPs have been implemented within the watershed starting in 1996. There are about 177 structural and 87 nonstructural (agronomic) BMPs implemented in the Mill Creek watershed.

TRWD has established four fixed sampling stations to gather water quality data and evaluate the effectiveness of the BMPs since 1996. Several water quality parameters were observed at the four fixed sampling stations in the Mill Creek Watershed. The water quality parameters monitored include total suspended solids (TSS) , total phosphorus (TP), organic phosphorus (OP), ammonia (NH_3-N), total Kjeldahl nitrogen (TKN), organic nitrogen (orgN), nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N), chlorophyll-a, dissolved oxygen, and carbonaceous Biological Oxygen Demand (CBOD). In addition to this, several USGS stations have collected water quality data on nutrients and sediments at the streams in the Richland-Chambers watershed from 1960's to 1980's prior to the construction of the Richland-Chambers reservoir in 1987. Since 1989 till the present day, TRWD has been periodically (monthly and quarterly) monitoring the water quality for nutrients and sediments at Richland and Chambers Creek as well as at various locations within the reservoir.

BMPs and conservation practices are designed and implemented to reduce nutrient and sediment loadings. Only a few studies have been able to verify the effectiveness of BMPs implemented. The BMPs installed in the Mill Creek watershed, the water quality data collected by TRWD at four locations within Mill Creek and the historical water quality data from USGS and TRWD provide a unique opportunity to verify the effectiveness of various BMPs implemented in this watershed and the changes in water quality in pre-BMP and post-BMP conditions. The major aspects of this study are to verify the effectiveness of installed BMPs in the Mill Creek watershed within the Richland-Chambers reservoir study area using observed water quality data and transfer the BMP data from the Mill Creek test site to other parts of the watershed primarily within the impaired segment of Chambers Creek (Segment 0814) to provide information on appropriate areas for BMP implementation in a cost effective way.

Objectives of the Project: The specific objectives of this proposal are to:

1) Verify the effectiveness of BMPs implemented by analyzing observed water quality data during pre-BMP and post-BMP conditions
2) Develop a methodology/modeling approach to make quantitative assessment of the effectiveness of conservation practices in reducing non-point source pollution in the – Chambers Creek Watershed by using observed water quality data for calibration and validation, and
3) Assess the spatial and temporal impacts of various BMPs at field scale and watershed scale, evaluate alternate BMPs and provide supporting information to aid the State Conservation Agencies in implementation of the BMPs in a cost effective way.

A watershed based modeling approach (with spatial/geographic information system capability) allows for considering the variations in weather, soils, land use and management practices in the watershed, and evaluating the impacts of conservation practices in terms of % of nonpoint source load reductions at different locations in the watershed. It is also possible to evaluate whether the existing management practices implemented are enough to meet the designated water uses/standards or not and also to identify what additional practices are needed to achieve the water quality standards. In studies funded by TSSWCB, Santhi et al. (2003) and Santhi and Srinivasan (2004) have applied similar modeling approach in the Big Cypress Creek Watershed and West Fork Watershed in Texas, for estimating the % load reduction due to implementation

of BMPs. The present study with good observed water quality data will aid in verifying the effectiveness of implemented BMPs and aid in transferring the knowledge of BMPs from the test site (Mill creek) to other parts of the watershed (Chamber creek segment 0814) to examine their impacts on water quality improvement and provide supporting information for BMP implementation.

Project Tasks:

Project Tasks, Deliverables and Schedule

Task 1. Develop a Quality Assurance Project Plan (QAPP)

Estimated Cost: Federal $2,400; Nonfederal $1,600; Total $4,000

Deliverables:
QAPP – A QAPP must be submitted to EPA, through the TSSWCB, 60 days prior to the initiation of any modeling.

Duration: Month 1-3

Task 2. Watershed data collection and Analysis

Estimated Cost: Federal $4,800; Nonfederal $3,200; Total $8,000

Subtask 2.1. Watershed data collection
Various data such as land use (current and historical), soil, topography, long-term weather data, crop management practices, stream flow and water quality data (current and historical) on sediment, nutrients, and pesticides for the Richland-Chambers Watershed will be collected from sources such as USGS, National Water-Quality Assessment (NAWQA) Program, TWDB, NRCS-Water Resources Assessment Team(WRAT), Blackland Research Center (BRC) , and TRWD.

Subtask 2.2. Information on BMPs implemented
Location, type, aerial extent and the farming practice of each BMP implemented in the watershed will be collected. Information on farming practices prior to BMP implementation will also be collected.

Subtask 2.3. Analysis of data
Data from Subtask 1.1 will be analyzed for trends in water quality and quantity to verify the effects of land use changes and BMPs implemented at Mill Creek on segment 0814 and Richland-Chambers Reservoir. Any long-term trends in the data will be further analyzed to verify if increasing or decreasing trends in water quantity correspond to the trends in water quality.

Deliverables:

- GIS maps related to soil, land use and topography of the watershed
- Compilation of observed water quality data collected for various sites from different sources

- GIS map showing the location of the various BMPs implementation sites in relation to 303(d)-listed segments
- Figures showing the time series of water quality data (sediment and nutrients) and any observed trends in water quality improvement due to BMP implementation and/or change in landuse.

Duration: Month 1 to 6

Task 3. Modeling of the BMPs at field and watershed scales using EPIC/APEX and SWAT

Estimated Cost: Federal $77,925; Nonfederal $51,950; Total $129,875

The Richland Chambers watershed will be delineated into sub-watersheds using the SWAT-ARCVIEW GIS interface. The map of the BMPs will be overlaid on the sub-watershed map to identify the BMP and non-BMP areas within each sub-watershed. The soil type and land use associated with the BMP and non-BMP areas will be identified using the GIS interface.

Subtask 3.1.
A field scale model (Erosion Productivity Impact Calculator – EPIC)/a farm-scale model (Agricultural Policy/Environmental eXtender - APEX) will be used to simulate the BMPs. The outputs from these models will provide benefits at edge of the field and will be input into the watershed model, Soil and Water Assessment Tool (SWAT). SWAT will provide benefits of the practices at sub-watershed and watershed levels after accounting for stream routing and losses.

Subtask 3.2.
Identify the main purpose of each BMP (whether the practice is meant for control of sediment, nutrients or bacteria) and identify the key processes/related parameters of the BMPs. After identifying the parameters/factors associated with each practice, represent them for pre and post-BMP conditions for model calibration.

Deliverables:
- Documentation of the modeling procedures for various BMPs modeled
- Documentation of the pre- and post-BMP farming conditions and model parameters adjusted/procedures adopted for pre- and post-BMP conditions

Duration: Month 6 - 20

Task 4. Model calibration and validation with existing data

Estimated Cost: Federal $61,998; Nonfederal $42,877; Total $104,875

Subtask 4. 1. Calibration and validation at field-scale
Literature information available from field-scale evaluation studies on BMPs will be used to parameterize the hydrologic and nutrient components, viz., flows, and sediment and nutrient loadings produced at field/farm level from the EPIC and APEX models. The parameters related

to various BMPs will be calibrated and validated using the observed water quality data as available at the Mill Creek watershed.

Subtask 4. 2. Calibration and validation at watershed scale
The SWAT model will be calibrated for streamflow, sediment, and nutrients using the monitoring data available from USGS stream gauges, and water quality monitored by TRWD and USGS at the reservoir and various stream segments. Model parameters related to (sub) watershed/landscape processes will be adjusted to match the measured and simulated flow, sediment loading and nutrient loading at key locations in each watershed as indicated in the study area. Then the model will be validated without adjusting any parameters.

Deliverables:

- Time series graphs showing the observed and simulated flows, sediment loading and nutrient loading for the calibration and validation periods as observed data available
- Statistical measures such as means, standard deviation, coefficient of determination (R^2), and Nash-Suttcliffe simulation efficiency (Nash and Suttcliffe, 1970) to show the model's prediction with respect to observed data at several locations in the watershed

Duration: Month 13 to 24

Task 5. Evaluation of the impacts of BMPs on water quality

Estimated Cost: Federal $46,200; Nonfederal $30,800; Total $77,000

Pre-BMP conditions representing conditions of the watershed prior to the implementation of BMPs, and post-BMP conditions representing the conditions of the watershed after implementation of the practices will be simulated to quantify the impacts of BMPs at different locations within the watershed. Changes in sediment and nutrient loadings between pre-BMP and post-BMP conditions provide information to assess the "long-term impacts" on water quality.

Deliverables:

- Results as percentage reductions in average annual sediment, total nitrogen (organic and mineral nitrogen) and total phosphorus (organic and mineral phosphorus) loadings at the farm level and at the watershed level.

Duration: Month 25 to 34

Task 6. Spatial and temporal analysis of the impacts of BMPs

Estimated Cost: Federal $42,000; Nonfederal $28,000; Total $70,000

EPIC/APEX and SWAT models simulate the hydrological processes such as hydrology, soil and water interaction, and crop growth and management on a daily time step (high temporal resolution), continuously and for long-term. The GIS capabilities available with the SWAT model allows for studying the spatial variability at high resolution (30m resolution). The proposed modeling approach

will be used to answer several "what if" questions. For example, apart from the existing BMPs implemented in these watersheds, effects of additional BMPs can be evaluated as follows:

- effect of implementing additional alternative BMPs that target critical areas to get maximum benefits

- time series/trend analyses on water quality at different locations using the model outputs to predict short-term and long-term water quality improvements

Deliverables:

- A map identifying sediment and nutrient hotspots within the watershed, suggestions for alternative BMPs and BMP locations, and the corresponding improvement in water quality in terms of percentage reductions in sediment and nutrients to the lake.

Duration: Month 25 to 34

Task 7. Project Report and Documentation

Estimated Cost: Federal $2,400; Nonfederal $1,600; Total $4,000

Final two months will be dedicated to writing project report and technical documentation of the project for submission to EPA, TSSWCB and referred journal articles.

Duration: Month 34 to 36

Project Management: Tasks 1 and 2 will be performed at the Spatial Sciences Laboratory (SSL), Texas Agricultural Experiment Station by Dr.Balaji Narasimhan. Dr. Santhi Chinnasamy and a PhD graduate student hired to work with her at the Blackland Research Center will complete the EPIC/APEX modeling component from tasks 3 to 7. Dr.Balaji Narasimhan at the SSL will do the SWAT modeling component. Overall Dr. R. Srinivasan, Professor and Director of Spatial Sciences Laboratory will provide project coordination and expert advice. TRWD will provide the needed field data on observed water quality, installed BMPs and other data as required in the project.

Project Coordination: TRWD is interested in the study and has extended their cooperation for this project. TRWD has established a good partnership with the stakeholders in implementing BMPs aimed at reducing pollutant loads in the Richland-Chambers Reservoir. The project will involve greater coordination with TRWD in obtaining observed water quality data and details of BMPs implemented.

The NRCS-WRAT at Temple is involved in modeling the atrazine in seven Texas Watersheds including the Richland Chambers Reservoir through funding supported by TSSWCB. This project is mainly focused on pesticide modeling and the project will estimate the benefits of BMPs implemented under 319(h) project in reducing atrazine loading. The project investigators will coordinate with NRCS-WRAT in sharing the data and modeling information. NRCS-WRAT will provide data on 319 BMPs and other water quality data. The investigators will provide NEXRAD rainfall data to NRCS-WRAT. The Texas Water Resources Institute (TWRI) is

working on a project in this watershed funded by EPA (Evaluating Water Quality Best Management Practices for Reservoirs in North Central Texas). The project investigators will coordinate with TWRI in sharing the data and modeling information so that there will be no duplication of efforts between the cooperating agencies.

Other agencies such as Texas State Soil and Water Conservation Board, Soil and Water Conservation Districts, USDA Natural Resources Conservation Service and EPA Region VI will be contacted as needed.

Measures of Success:
We expect the hybrid model (SWAT and EPIC/APEX) to quantify well the effectiveness of BMP's (e.g. reduction of sediment and/or nutrient load in t/year) by calibrating and validating the model using observed water quality data. We also expect that the modeling approach will be useful to identify critical areas for additional BMP implementation to further improve the stream/lake water quality. We also expect that this study will be a forerunner for several non-point source TMDL exercises across the state and the country.

References:

1) Nash, J. E., and J. V. Suttcliffe. 1970. River flow forecasting through conceptual models, Part I – discussion of principles. Journal of Hydrology 10(3), 282-290.

2) Santhi, C., and R. Srinivasan, 2004. Mapping and Modeling of the Water Quality Management Plans Implemented in the West Fork Watershed of Trinity River, Blackland Research and Extension Center, Texas Agricultural Experiment Station, Texas A& M University System, Temple, TX, BRC Report No. 04-05.

3) Santhi, C., R. Srinivasan, J. G. Arnold, J. R. Williams. 2003. A Modeling Approach to Evaluate the Impacts of Water Quality Management Plans Implemented in the Big Cypress Creek Watershed. Second Conference on Watershed Management to Meet Emerging TMDL Environmental Regulations, Albuquerque, New Mexico, November 2003, pp: 384-394.

OBJECT CLASS BUDGET
for the
Best Management Practice Verification Project (04-18)
Texas Agricultural Experiment Station – Blackland Research and Extension Center

Object Class Category	**Federal Funds**	**Non-Federal Match**	**Total Costs**
Personnel	$140,462	$59,897	$200,359
Fringe Benefits	$34,174	$13,790	$47,964
Subtotal Personnel & Fringe	$174,636	$73,687	$248,323
Travel	$3,750	$0	$3,750
Supplies	$7,246	$0	$7,246
Other	$16,432		$16,432
Contractual	$0	$0	$0
Total Direct Costs	$202,064	$73,687	$275,751
Indirect (15% Rate)	$35,659	$33,528	$69,187
Unrecovered IDC		$52,812	$52,812
Total Project Costs	**$237,723**	**$160,027**	**$397,750**

Budget Justification:

Personnel

Salaries and Wages

We are planning to hire one graduate student for years 2 and 3. The student will work on the project half-time (50%) at $16,800/yr. The graduate assistantship stipends are the standard departmental rates for a PhD student in Forest science. The graduate student along with the post-doc will work on various modeling components. The post-doctoral research associates will work on this project – one will work 55% and the other will work 25%. One post-doc will work on developing a link between EPIC/APEX model and SWAT. The other will work on EPIC/APEX model and parameterize the model inputs for various BMPs. The computer administrator to support the computing needs of the project will be covered by state funds at 20% effort. The project leader's effort of 1.1 month will also be covered by state funds.

Salaries & wages (3 years): Federal - $177,635; State - $73,687; Total – $251,322.

Travel

Domestic Travel

Travel would involve site visits and project meetings with TRWD and TSSWCB. We would also like to present the results to the scientific community at every stage of our research. The research will be of interest to the agricultural scientific community. So we decided to participate and present our results in the international meetings of ASAE (American Society of Agricultural Engineers) and AWRA (American Water Resource Association) annual conference. Graduate students and Post-doctoral trainee will be given the opportunity to present and participate in the conference. The conference fees for ASAE and AWRA are approximately $400 for members and $100 for student members.

Total travel: Federal - $3,750; State - $0; Total - $3,750.

Other Direct Costs

Materials and Supplies

Supplies and materials requested in the project ($1500 per year) are to cover expendable supplies for the Spatial Sciences Laboratory to cover the cost of data storage devices like floppy disks, and recordable CD-ROM's. The cost will also cover the cost of printer and copier supplies while preparing reports. In addition a computer will be bought during the first year ($2500) for data storage and modeling purpose.

Publication Costs/Page Charges

The results of this research will be published in water research journals such as Journal of American Water Resources Association and the Transactions of the ASAE because of their wide audience. The Publication cost per page journals for members is approximately $75-$100 per page. We are expecting to publish four papers from this research.

Graduate Student Tuition Assistance
The graduate student tuition assistance will cover the student tuition expenses ($6,216/year) as required by Texas A&M University policy for projects employing graduate assistants.

Other direct cost:	**Federal – $20,678;**	**State - $0;**	**Total – $20,678.**
Total direct cost:	**Federal - $202,064;**	**State - $73,687;**	**Total – $275,750.**

Indirect Cost
The indirect cost was calculated at a Texas A&M negotiated rate of 45.5% on total federal funds. 15% IDC on total federal funds will be covered by Federal dollars and rest (30.5%) will be matched by state dollars.

Total indirect direct Costs:	**Federal - $35,659;**	**State – 86,339;**	**Total – 121,998.**

Total Project Cost

Total project cost:	**Federal – 237,723;**	**State – 160,027;**	**Total - $397,750.**